Conn. (G.P.)

VENTILATION

— BY —

G. P. CONN, M. D.

Compliments of the Author.

OBSERVATIONS

UPON THE

IMPORTANCE AND

MEANS OF VENTILATION.

BY

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CONCORD.

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It is an old saying, that air and water are free to all, and are to be had "without money and without price." In the abstract this is true, yet in the practical application of this aphorism, there is found to be manifold difficulties in the way of acquiring and maintaining the absolute purity of either of these essential elements of life and health, except by the expenditure of money in the introduction of them into our dwellings, places of business, and public buildings, as well as in protecting them from contamination by waste and effete matter.

Scientific observation has established the fact, that unless the purity of air and water is made secure, those residing within the circumference of a contaminated atmosphere or a polluted water supply will, within a limited period, suffer in proportion to the amount that either has been defiled. In New England, nature has provided in abundance both of these elements of life and health, yet she has not erected automatic safeguards against either becoming poisoned, by the carelessness or the ignorance of the public.

Man having been "created a little lower than the angels," endowed with the gift of reason, invested with the powers of observation, sensation, and discrimination, thereby being rendered capable of self-improvement, culture, and civilization, at once becomes the architect of his own fortunes, and responsible for the sanitary condition that surrounds his habitation.

It matters not that there may be vast differences in the mental characteristics of the people of the state or nation, none are so dull, save those absolutely bereft of reason, but they can be

taught the elements of self-culture and perception; therefore it is plainly the duty of governments to provide the means of developing the minds of the masses, and of individuals, whose attainments are in advance of their less favored compatriots, to contribute by their example and by precept to the social elevation of the community and country in which they live.

In a climate like New Hampshire, in which for more than half the year artificial heat is required to render our homes comfortable, it is probable that ventilation is more generally neglected than any other of the fundamental principles of sanitary law. This is partly due to inattention and to ignorance of the laws governing the diffusion of gaseous bodies, but more generally, and quite too often, from the fact that it is expensive to warm a current of pure air from the outside of our habitations when the temperature is near zero, and, after exhausting its oxygen by respiration, allow it to escape in order that a fresh supply may be received.

The era of modern improvements in our dwellings and in our places of business has so far increased the cost of living that in order to gratify this love of luxury and modern æsthetic notions, it has become altogether too much the prevailing custom to construct public and private buildings with more regard for display than for stability and recognized hygienic principles.

Glazed paper, so often poisonous, colored walls, showy gas-fixtures, beautiful curtains, and costly carpets seem to impress the minds of the masses as being of far more importance to their comfort and well-being than any thought of whether the house in which they are to live is situated upon dry ground, is well ventilated, and has good drains and plenty of sunlight.

Here is an extensive field for sanitary study that most intimately concerns us all; for, however carefully we may construct our own dwellings and guard them against the contaminating influences of the immediate neighborhood, we have no control over the construction of public buildings, nor can we escape the evil influences connected with their faulty construction or their want of proper ventilation.

The term ventilation, signifying "to fan with wind," when applied to buildings, resolves itself into one broad general principle—the admission of pure air into the different rooms and the

expulsion of the air which was confined within the same cubic space.

This is a self-evident proposition, for, without the aid of costly machinery for the compression of the atmosphere, no more air can enter a given space than is in some way removed, and to expect it would be as unphilosophical as it would be to attempt to make a cask filled with water receive a few gallons more without first withdrawing an amount quite equal to the quantity we desire to dispose of. This proposition does not involve any complex problem, and would seem so simple that any well balanced mind would solve it, were it not for the lamentable ignorance which prevails regarding the laws of life. The sublime indifference of many people as to the comfort and well-being of anybody except themselves; the tendency to procrastination in little matters where expense is involved; the prevailing custom of living in the style and manner of others, rather than to think and act for themselves; the ambition to have dwellings with modern improvements before they have the pecuniary ability to buy or rent any but those of the cheapest construction; the disposition that prevails among the people to place confidence in others on questions of the most vital importance, when the health and lives of their families are in peril, rather than calmly to investigate the cause and effect of existing circumstances; the fact that brass and brazen effrontery pass current for scientific research and practical knowledge; the convenience of placing responsibility upon some one else rather than to assume our own share of the burden,—these and many other reasons serve to render it a complicated question, and it will remain as such until it is divested of sophistry, and is met with the calm assurance of practical common-sense. The objects of ventilation are, to secure a continual and adequate supply of pure air, and to remove the impurities that accumulate within a room along with the atmosphere which holds them in suspension.

The importance of air space depends upon the absolute necessity of pure air for healthy respiration; but the cubic amount of space required must always be governed by a variety of circumstances, the chief of which is the rapidity with which it can be changed or renewed, so that respiration can be effected without breathing the same atmosphere a second time.

The sick and infirm must necessarily have the largest amount of space, from the fact of their inability to move about or to be in the open air; and our sleeping-rooms, where we spend nearly or quite one third of our whole lives, should receive especial consideration.

It is quite too often found in the modern house, that the parlor, which is only occasionally open, has received the lion's share of space, while the sleeping apartment is only a small 8 by 10 room, that in the estimation of the builder could not be utilized for any other purpose.

Again: it is quite too common in a house where there is a good-sized and well-lighted room to be used for a sleeping apartment, to find it set apart for the use of an occasional guest, and rarely occupied more than a few times in a year, while the family have to put up with close, dark, and ill-ventilated rooms every night.

Let us for a moment consider the nature and the character of the noxious matters found in our living and sleeping-rooms, as well as in public assembly halls and places of business. Whence does it emanate ?

Every human being is constantly throwing off from the lungs, skin, and otherwise, about as much in weight as is from day to day received in food, drink, and respiration. We take into our system inorganic compounds of atmosphere and water, as well as disorganized, though recently living, grains, fruit, roots, animal food, &c.

We organize or consume them, and after they have served their purpose in sustaining our life and strength, they are again thrown off to be rapidly decomposed. The higher the life they have attained, the more noxious they become in their effete molecular death.

An adequate supply of free oxygen is absolutely necessary to sustain animal life, and the higher we ascend in the scale of organized life, the larger the quantity of oxygen consumed, and the more imperative the necessity for its consumption.

In the atmosphere, oxygen exists in a free state, in mechanical solution, and in the form and proportions that admit of its being most easily assimilated. From the atmosphere the animal absorbs oxygen by means of its respiratory organs, which provide

for its absorption by the blood, and through the blood-vessels it is carried to all the tissues.

Air becomes vitiated and unfit for respiration by holding in solution other gases or substances whose presence interferes with the appropriation of oxygen by the animal, or, being themselves absorbed, they have a poisonous influence upon the vitality and the tissues of the animal, and, interfering with nutrition, languor and prostration follow as a natural sequence.

Pure air, which nature intends for all the animal creation to breathe, is a mechanical mixture of twenty-one parts of oxygen with seventy-nine parts of nitrogen.

On an average, a person will inhale about twenty cubic inches at each respiration, and, allowing eighteen respiratory movements to take place each minute, it will require three hundred and sixty cubic inches per minute, and twenty-one thousand six hundred cubic inches, or twelve cubic feet, in one hour. Therefore one person requires about three hundred cubic feet of air in twenty-four hours, and fifteen thousand cubic feet would be necessary for fifty persons in the same period.

Take for example a hall 40 by 50 feet on the floor and fifteen feet high, and it has 30,000 cubic feet of air space, which would allow 300 cubic feet to each of one hundred persons; yet if it were constructed in such a manner as absolutely to exclude any fresh air from passing into the room, it would only furnish the requisite quantity of oxygen to supply fifteen persons one hour without becoming contaminated. Of course, this number of people could live for a considerable period more than one hour in such a room, but it would be in an atmosphere of filth, and each succeeding hour would largely increase the liability of contracting or of developing contagious or infectious disease. Fortunately for the life and health of the people, it is not the custom to hermetically seal rooms intended for habitation, nor has the builder's art become so far perfected as to completely exclude fresh air from entering about doors and windows, to say nothing of the loose manner in which much of contract-work is done. It has been observed that every person requires about twenty cubic inches of fresh air at each inspiration; and to understand how confined air becomes unfit for respiration, we must take into account the fact, that for every inspiration a person takes, an exhalation must surely follow, and that the twenty-one parts of oxygen inhaled

have been exhausted from the air and used by the lungs in supplying the blood with vitality to support life, while in its place we find carbonic acid given off with watery vapor, neither of which will sustain life, and therefore should not be used in respiration.

Thus the inevitable result of using a room for any purpose wherein people congregate together is to exhaust the oxygen or life-giving property of the atmosphere, and with every breath contaminate the remaining portion with a subtle poison; for carbonic acid will neither support life nor combustion. And, as soon as the air of a room *becomes contaminated with it to the amount of four per cent., it is dangerous to life; and ten per cent. is fatal at once.*

Odors being volatile and exceedingly light, rise at once to the highest portions of a room, and, if not allowed to escape, accumulate there, saturating the air from above downwards, finally reaching the floor. They then become perceptible to the senses; but there can be no doubt of the fact that the atmosphere was capable of harm long before its baleful influence was recognizable.

This organic matter is our most deadly foe, since it so quickly undergoes decomposition; and it becomes rapidly prostrating, with a sensation of stifling and nausea. It is this we may perceive, on coming from the outer air with the sense of smell unblunted, and entering a small room that has been closed and occupied during the night. Fresh air is the natural disinfectant, antiseptic, and purifier, and nothing has been developed in art to supply its place, or render animal life less susceptible to injury because of its being impure.

There is plenty of it in the world, and it was the design of the "Creator of all things" that every man, woman, and child, yea, every living thing, should receive its full quota fresh from the boundless area of the atmospheric belt, and uncontaminated by neglect or by the ignorance of others,—the amount to be unlimited and amply sufficient to dilute and quickly remove all that has been rendered impure by respiration and combustion, as well as by the mixture of dead organic particles that the skin and lungs are constantly throwing off.

To neutralize the deleterious properties of air that has been used in the act of respiration, and to provide for its renewal in

sufficient quantity to render it a healthy atmosphere to breathe again, provision should be made whereby every person can receive two thousand cubic feet of fresh air every hour.

Any design for the ventilation of a room that fails to secure a constant and unfailing amount equal to this is either faulty in its construction, or is imperfect in practical work. The poisonous effluvia which pervades the atmosphere of close and unventilated rooms is not only rebreathed, but it adheres to all the surroundings, sticks to the walls and furniture, settles into the drinking-cup, into food utensils and food and drink, permeates clothing, and attaches itself to the person. It creates a nidus which is not only in itself poisonous, perpetually lessening the vital force of all who inhabit such rooms and predisposing to blood-poisons of every kind, but it also becomes a hot-bed for the planting and propagation of specific poisons, such as small-pox, scarlet fever, measles, whooping-cough, diphtheria, and the whole catalogue of epidemic diseases, as well as being a fruitful source of consumption.

A German scientist has demonstrated, by experiments upon the inferior animals, that it is only necessary to keep rabbits and guinea pigs about three months in a small, close apartment, in which the air is more or less vitiated by the carbonic acid which they exhale from their own lungs, to develop tubercles, the initial state of consumption; and it has been the observation of medical men in this country, that certain types of disease that are wasting in character, like consumption and marasmus, have become far more prevalent within the past fifty years. Experiments like the preceding are interesting and important in seeking for the causes of any disease. It is generally understood that such forms of disease are comparatively rare among the pioneers in new settlements, and many a man has found relief and comfortable health among the mountains in the far West, after his case seemed hopeless amid the luxurious surroundings of modern improvements. The pioneer's log house, erected without any regard to architectural design, on dry ground, and exposed to the elements on all sides, has its peculiar advantages; for, although limited in space to one or two rooms, whose outside walls admit fresh air without limiting its quantity or contaminating its quality, its primitive but capacious fire-place and ample chimney afford a

speedy transit for all odors and impurities, and are ever constantly changing the atmosphere of the whole house. While a continued residence in such habitations has its varied hardships and privations, the glow of perfect health, and the sturdy physical endurance which it develops, have a peculiarly fascinating influence that is unknown to those dwelling in crowded cities, and breathing the vitiated atmosphere of rooms warmed by air-tight stoves, and sleeping in box-like apartments in which the breath from the occupant's lungs is constantly contaminating the limited quantity of air allotted for his use.

The great plains and mountain ranches of the West furnish habitations for many a young man just out of the classic halls of our college buildings, in which, by close attention and study in the vitiated atmosphere of badly ventilated rooms, health was undermined, mental ambition found itself supported by a feeble physical frame, and, to recuperate the exhausted energies of a failing constitution, it became necessary to live in an atmosphere uncontaminated by the exhalations that always exist when people are massed together.

Such as have the courage and fortitude necessary to endure a pioneer's life in cabins so open that the supply of pure air is unlimited, and each respiratory movement secures for the lungs a full supply of free oxygen unpolluted by the carbonic acid exhaled, soon experience the vigor of returning health and strength; and it is not to be wondered at that such people are unsparing in their praise of a climate that renders them robust, and capable of so much physical endurance.

It is quite true that all do not inherit equal vitality, and that some seem totally unfitted by nature to stand the strain upon the system imposed by a residence in a constantly changing climate like that of New England; yet any one who has inherited a feeble constitution, or by accident has acquired a tendency to disease, can have no more certain way to foster and develop these unfortunate predispositions than by living in close, unventilated apartments. Some are endowed with far greater powers of endurance and resistance than others, and will bear up longer, but all are injured to a greater or less extent, and will sooner or later show the effects of disease.

Human beings wish to live, and yet they are ever transgress-

ing the laws of physical life, obeying which, accidents excepted, long life would be almost absolutely certain. Let us have fresh air. It is better to expend money in providing it in abundance than it is to expend it upon the daily attendance of a physician who cannot cure those who are ill, nor prevent the well from becoming sick, when they are exposed to the contaminations of a foul, polluted atmosphere.

There should be no mystery in the cause of disease. Not once in a thousand times does it arise from anything else than some error in our manner of living. We are very foolish, as well as very blind, not to take cognizance of the surroundings of our homes, and labor to place them in perfect sanitary condition, instead of spending money on carven work and ornamentation.

In discussing the various arrangements to perfect ventilation, it is necessary to bear in mind some familiar properties of the atmosphere, generally lost sight of, or misrepresented by the partisans of special devices, in which they have a monetary interest.

The atmosphere is simply two gases held in mechanical solution,—a perfectly elastic body, expanding when warmed, becoming lighter volume for volume, in proportion to this expansion;—hence warm air floats to the top of cool air as oil floats upon water. The law of diffusion of gases expresses a truth, but this diffusion is so slow that practically it may be omitted in calculations in which circulation comes into account. The condition of heat in gases is similarly slow and insignificant.

The atmosphere of a room, and its walls, are mainly warmed by radiation and the introduction of warm air. Air once breathed is warmed in the lungs to about 35° C., or 95° F., and that which carries off the insensible perspiration is similarly warmed by the surface of the body,—which explains why the temperature of an ill ventilated room rises so rapidly when occupied by more people than the architect has provided fresh air for, and where an audience will experience a feeling of languor, and the more feeble ones actual headache.

Bear these mechanical principles in mind, and you will be prepared to study the subject of ventilation in a practical manner.

The natural motion of the atmosphere is the wind, and it is our great power in ventilation for health. Very large buildings, vessels, deep mines, and tunnels, often require it to be produced

artifically by a fan propelled by power, to keep the air of such places in motion; but in small buildings our principal duty is to prevent needless interference with this great force of nature.

We must spend a part of the time in the open air. We should allow the wind to blow through our houses and under them. The skin should not be varnished nor gilded, nor should we wear close-fitting rubber or patent-leather clothing. Bed-clothing should be spread out to air, with windows open, a part of every day, so that articles damp with perspiration need not be covered up in making up the beds.

The soiled clothing of healthy people, if kept in close bundles and unventilated closets without being washed, will in a short period become dangerous, and may develop the germs of infectious disease. Dr. Lind* informs us "that the washer-women, taking bundles of clothes from recently arrived ships, died in considerable numbers of typhus or ship fever, and carried the contagion abroad, until they adopted the habit of first spreading the clothing upon the grass and sand in the open air."

The crowding of people together without sufficient air-space is a well-known source of epidemic and contagious disease, oftentimes more fatal to those coming in contact accidentally, for short periods, than to the occupants of such ill-ventilated quarters, who may have become somewhat accustomed to the confined air and filth, thereby rendering them comparatively unaffected by its influence.

True and effectual ventilation consists in the free access of pure air, and the escape of foul or polluted atmosphere. Any of the many ingenious devices for heat and ventilation that are deficient in either of these absolutely essential conditions are useless in proportion as they are deficient. Airing and warming are not inconsistent, but the facility with which this may be accomplished depends upon various circumstances. The warming and ventilating of an ordinary parlor, a chamber, or a private house, may be effected by means that would not be practical in providing for a large assembly-room, a hall, or a school-house.

The art of warming and ventilating a house or an apartment consists in adapting the means used to the end to be accomplished,

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* Diseases of Europeans in Warm Climates.

without sacrificing the essential conditions; and if the proposed design cannot be so adapted, then in all cases it should be discarded, and other means devised to effect a desirable result.

This is a self-evident truth; for a means of heating a room or a building ever so hot without at the same time affording ample and systematic ventilation is as inconsistent as would be the construction of a building for habitation with unlimited ventilation, and not provide the means of comfortably warming it for the use of the occupants.

As to the best manner of ventilating public and private buildings, there is and has been a great diversity of opinion; and it is not probable that the same system can be made equally effective under so many and varied conditions as are required to meet the wants of our different styles of architecture, our changes in climate, and the real or fancied necessities of individuals. Yet the principles are ever the same in theory, and must be rendered practical by sound reasoning rather than by adherence to any hobby. For it matters not what the architectural design of a building or a room may be. In order to ventilate it, the air must be changed, and to do that effectually and with due regard to health, the fresh supply to effect that change must be derived from the outside instead of being taken from other rooms within the same building.

In New Hampshire it becomes almost a necessity to combine the heating and ventilation of buildings under the same system, since the air must be warmed during the greater portion of the year before it is brought into our rooms in such quantities as are necessary to furnish the change that is desirable for health and comfort.

The Connecticut State Board of Health, in their third annual report, publish the experiments of the architect, Warren R. Briggs, of Bridgeport, as to the best manner of introducing pure air into rooms, warmed to a degree necessary for the comfort of those living therein, as well as the best position for the outlet for the air in the room after being used for respiratory purposes. These experiments were carefully conducted, and the illustrations, which are herewith inserted, are reproduced through the courtesy and permission of Mr. Briggs and the State Board of Health of Connecticut, who have kindly loaned the plates for this report.

The experiments were conducted for the purpose of demonstrating the best manner of warming and ventilating schoolrooms having a capacity of about 13,000 cubic feet, and the model used in making these experiments was about one sixth of the capacity of the rooms intended for the practical use of the system: yet the principles involved, and the deductions that are brought out, are as applicable to dwellings and places of business as they are to school buildings.

The method employed to demonstrate the movement of the air in the room was to fill the incoming flue with smoke, when the change effected by the diffusion of fresh air with that already in the room could be made clear to an ordinary observer from the time it entered the room until it passed out through the out-cast flue.

It was the aim of the architect to utilize all the heat possible, and at the same time secure a perfect change of air in every part of the room: therefore the inlet and the outlet were changed to various points between floor and ceiling in order to determine how this could best be accomplished, and as is illustrated in the following figures.

The first design shows the effect of air introduced through an inlet in the floor near one side of a room, the outlet being near the top of the room on the opposite side, and the second figure, the outlet being the same as in the first figure, the inlet is changed to a point more than half way from floor to ceiling; yet in neither does it appear that the air is much changed except in the upper part of the room.

In explanation of the other figures, I will quote from the author. Mr. Briggs says,—

The air entering upon the outer wall at the floor and being removed on the inner wall at the ceiling-level, does not benefit the occupants of the room as it should. The action of the air as it enters is rapidly upward to the ceiling, where it stratifies, then along its surface to the outlet, as indicated in Fig. 2. The entering air is warm and light, and naturally rises and flows across the top of the room to the nearest outlet. The foul air of the room being heavy with impurities, remains at the bottom, becoming constantly more contaminated. There is, no doubt, a certain amount of radiation or mixing going on but the great

bulk of the pure warmed air entering the room takes a short cut across it and up the ventilating-duct, as shown in Fig. 2.

FIG. 2

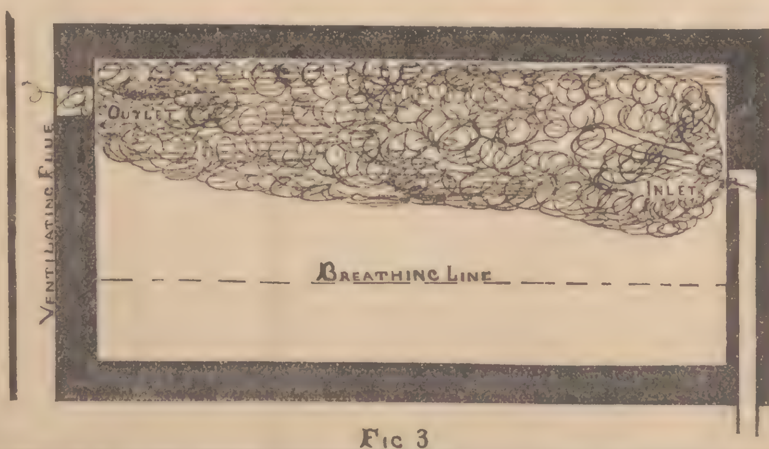

FIG 3

This action of the warm air occasions, as may be readily seen, an enormous loss of heat, without accomplishing the very points aimed at,—the utilization of every particle of heat before it is

allowed to escape, and the thorough mixing of the pure incoming air with the air already in the room. If any one doubts the correctness of the action of air as herein described, let him fill the incoming flue with smoke that can be readily seen, and watch its course as it enters, flows upward and outward, and see where the great mass of it goes. The dotted lines on these sketches indicate the breathing point of a person sitting.

It may be well to explain that in these experiments that I have made, the outlets have been at least *twice as large* as the inlets, and that there has always been heat in the outgoing flues to produce a strong up-current, as I believe this to be the *only* sure way to produce a constant outward flow of air.

In Fig. 4, the flues have been placed on about the same level,

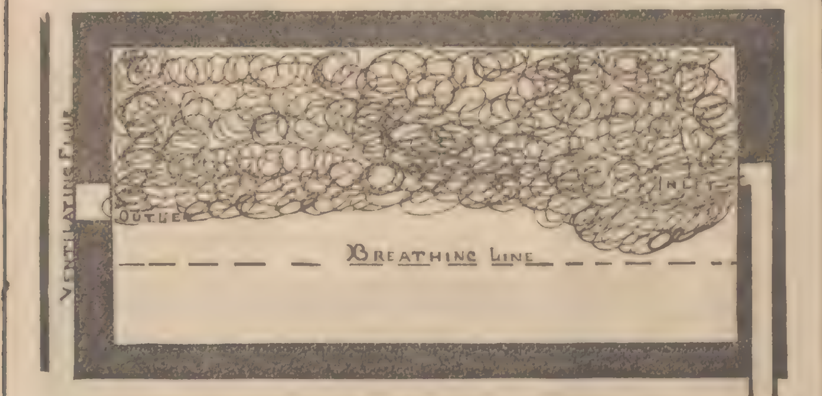

FIG 4

but with no better results. In Fig. 5, the outgoing flue has been placed at the floor with the results shown in the sketch. In Fig. 6, both flues are at the floor-level with better results than have yet been obtained, but still far from satisfactory. I have thus tried to show the general action of incoming and outgoing currents of air by the placing of the introduction-flues on the outer walls, and the outlets on the inner.

The second method in general use is the placing of the coil-boxes upon the inner wall, and the removal of the foul air at the opposite or outer side of the rooms.

I consider the placing of the coil-boxes on the inner wall a great improvement on the other method, as by this plan they are centralized, extensive piping is saved, and the danger of freezing obviated.

The placing of the exhaust-flues on the opposite side of the room I believe to be open to the same objections that I have described in the first method. The action of the hot air from the points where it is introduced towards the various outlets is the same as in the sketches already shown, and will be readily understood by the reader.

In the Bridgeport school the coil-boxes for the heating of the various rooms have all been placed in the main ventilating shafts in the *centre* of the building, and the air conveyed from them through these shafts to the rooms by means of metal tubes.

The air enters the inner corner of the room about eight feet from the floor, the corner being clipped so as to form a flat surface for the register opening; underneath the register the space is utilized for a closet for the use of the teacher. The outgoing

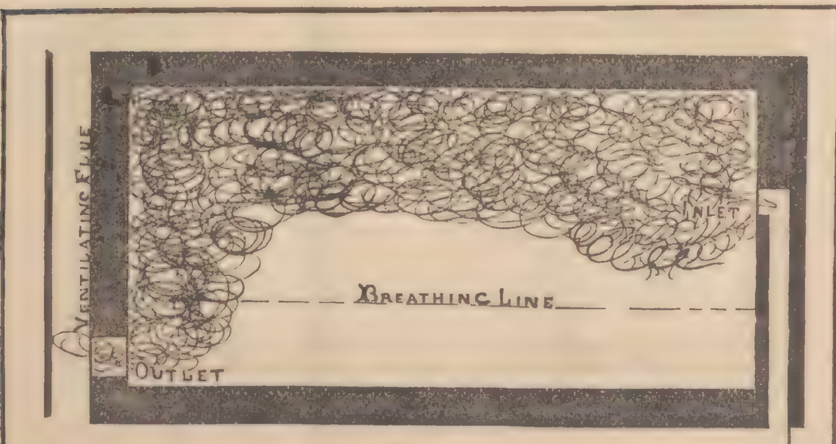

FIG 5

flue has been placed directly under the platform, which is located in the *same corner* as the introduction flue.

This platform is 6 × 12 feet, and is supplied with castors, so that it can be moved at any time it is necessary to clean under it. Its entire lower edge is kept about 4 inches from the floor to give a full circulation of air under it at all points. The action of the incoming air is rapidly upward and outward, stratifying as it goes toward the cooler outer walls, thence flowing down their surfaces to the floor, and back across the floor to the outgoing register on the inner corner of the room.

By this method, all the air entering is made to traverse with a circular motion (see Fig. 7) the entire room, before it reaches the

exhaust-shaft, and there is a constant movement and mixing of the air, in all parts of the room, continually going on. All the heat entering is utilized, and I believe that if the supply- and exhaust-flues are properly balanced as to size, there can be but a very small loss of heat.

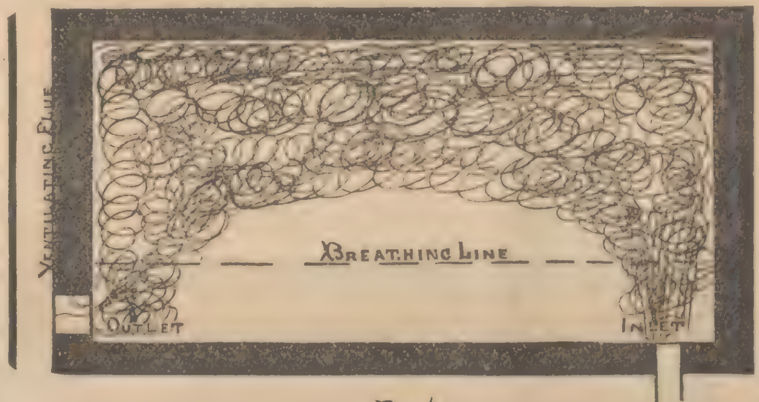

Fig 6.

The inlets are all intended to be large, and the flow of air through them moderate and steady. The air is not intended to be heated to a very high temperature: the large quantity introduced is expected to keep the thermometer at about 68° at the breathing-level. The school-rooms contain on an average about 13,000 feet of air, or 260 cubic feet per pupil. It is proposed to supply each pupil with 30 cubic feet of air each minute, or 1,800 cubic feet per hour.

Allowing fifty pupils to each room, this will necessitate the introduction of 90,000 cubic feet of air into the room each hour, and will change the air of the room 6.92 times within the hour, or once in about eight minutes. These calculations are based on a difference of 30° in temperature.

In the exhaust flues there are placed coils to produce a strong up current at all times; heat is also obtained from radiation from the introduction and boiler-flues, which run through the foul-air shafts.

Trouble has always been found in regulating the supply of warmed air obtained by the indirect system, owing to the inability to control the heating surfaces. The usual way of constructing the apparatus has been to place in the coil-boxes sufficient steam-pipe to heat the room in the coldest weather. The

pure, cold air passing over the pipes becomes heated to the desired temperature, and is then carried to the rooms; this answers very well during the coldest weather, but as the weather moderates and less heat is required, the only way to regulate it has

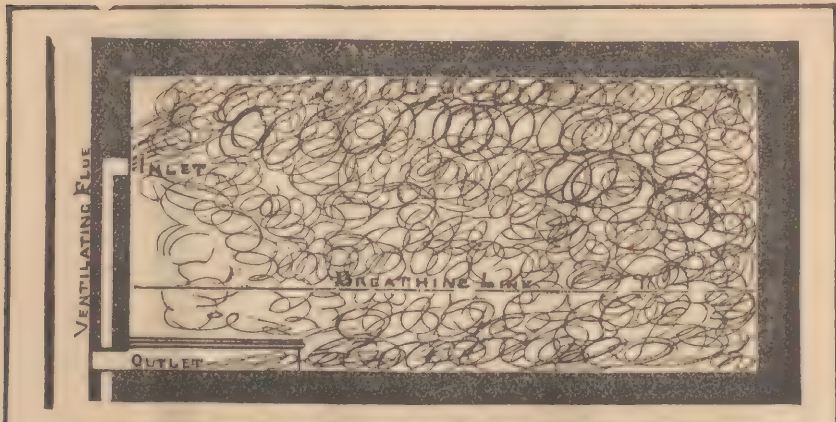

Fig 7

been to close the registers. This not only lowers the temperature of the room, but shuts off the supply of pure air entering. This fault has been remedied in the Bridgeport school-house as follows: The heating surface for each room is enclosed in separate cases or jackets (see Fig. 8) of metal, and are then subdivided into five sections, so arranged that any number of sections, or the whole, may be used at pleasure,—that is to say, that any one, two, or three parts may be used at discretion. In extreme cold weather the whole five sections are in use; in moderate weather, two or three; and when a small amount of heat is required, only one. By this plan the supply of pure air remains always the same, but the degree to which it is heated is changed by the opening or closing of a valve. (See sketch.)

The above method of regulating the temperature of a room or a building, when warmed by steam, is at once simple and effective, and does away with many reasons against its use, for in practice it has been found almost impossible to adapt the system to the varied conditions of our climate. We often have a difference of twenty to thirty degrees of temperature in twenty-four hours, and with a single coil of steam-pipes it is not practicable

to have the rooms comfortable in the coldest periods, and not have them uncomfortably warm when the outdoor temperature becomes

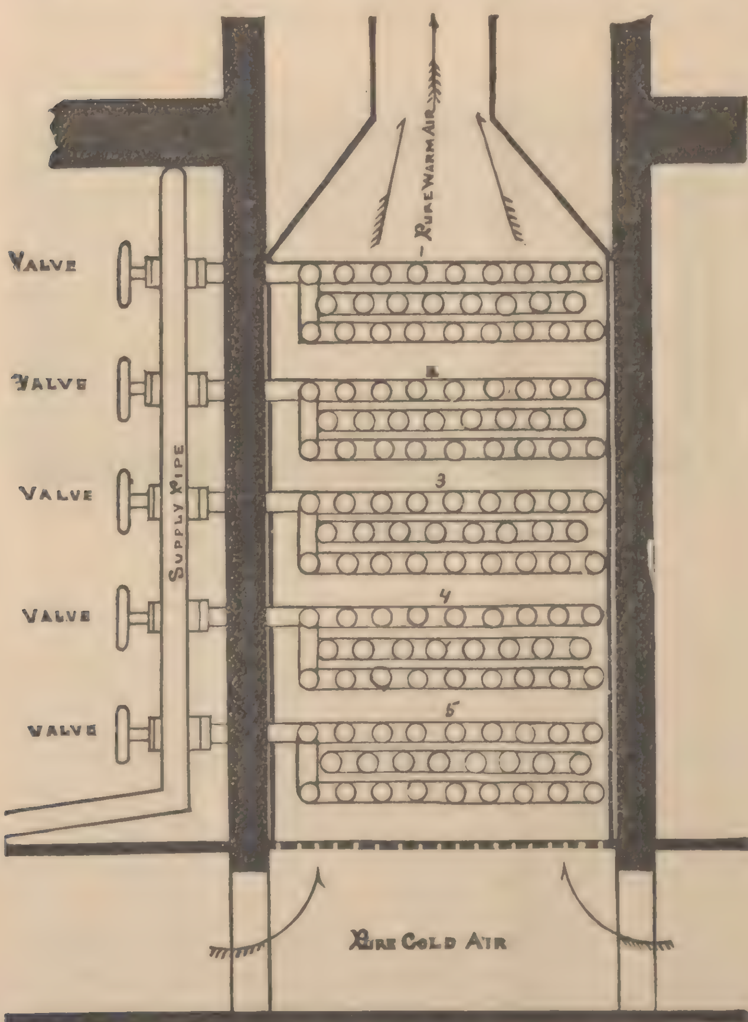

FIG. 8.

higher; but with several coils of pipe, each independent of the others, these changes can be met and adjusted without exposing

the inmates to direct draughts from windows to cool overheated apartments, nor to the discomfort of cold rooms for hours because the thermometer in the open air has dropped below zero for a few days.

For warming and ventilating churches, public buildings, halls, and large private dwellings, in which steam is to be employed as the agent to accomplish the object, the plan above described offers a plain, common-sense method, comprehensive in all its details, and should commend itself to those having works of this kind under consideration.

The olden time fire-place had its peculiar advantages in ventilating the apartments in which they were situated; and no one will dispute that they still have an attractive appearance, as well as a charming influence, in the family circle wherever they are to be found. The only objection is and has been, they are expensive, as they are great consumers of fuel, and much of the heat generated within their glowing sides is lost by being carried up the flue with the air which they remove from the room.

Mechanics and practical men have for a long time been pondering over the problem how the fire-place of our fathers could be restored in principle, and economy in fuel maintained at a minimum of expense.

The open grate has always been a favorite in our homes, and it is only because in the ordinary form it is such a great consumer of fuel and so feeble in its heating capacity that it has been supplanted by other and more economical kinds of heating apparatus.

Mr. Edwin A. Jackson, of New York, has placed before the public a modification of the Galton fire-place and grate, combined in such a manner as to give it superior heating power and perfect ventilating capacity.

In perfecting this most excellent device to meet the requisite conditions to render our homes comfortable and healthful, the designer has rendered valuable service to the people, for he has so far remodelled the ordinary grate that a large percentage of the heat can be saved, and at the same time preserve the chimney flue for ventilating purposes.

The ordinary grate will remove much of the noxious air from a room in which it is situated, but it takes its supply of fresh air

from the doors and windows, or through the crevices surrounding them, thereby creating drafts of cold air which are uncomfortable, and not free from deleterious results.

Mr. Jackson's ventilating grate seeks to avoid these objections, as will be seen from the following description of the manner in which it is constructed, and the principles involved in its operation.

Fig. 9.—*Front.*

The accompanying illustrations have been made from plates loaned to the State Board of Health by Messrs. Jackson, of New York, and they will enable the reader to comprehend, at a glance, that the design is based upon a scientific principle, inasmuch as it provides fully for the entrance of pure air from outside the house, and the exit of the air in the room where it is placed:

Figure 10 shows the construction of the heat-saving chambers in the Jackson Fire-place, the outer shell being in part broken away. Pure air from outdoors is admitted through the opening shown in the base of the cut, and is distributed by the heated spurs there represented to the chambers directly back of and on the sides of the fire. From these chambers the now partially heated air enters the chamber shown at the top of the cut, through which the four smoke flues are seen to pass. These also imparting a large portion of their heat to the passing current, its temperature is raised to 150 degrees or 200 degrees (according to the

Fig. 10.—*Back.*

intensity of the fire), and it now passes a volume of pure air either directly into the room through the openings shown in the frieze of the grate (Fig. 9), or, at the option of the owner, up a pipe to a room on the floor above. It will be seen, by an inspection of the diagrams above, that, in construction, the Heat-Saving and Ventilating Grate essentially consists of an inner shell, against which the fire rests, or is in close contiguity, and an outer shell, which lines the brickwork of the fire-place. The inner shell has projecting from its back a great number of spurs or spikes, which increase the extent of its radiating surface, and serve as conductors in conveying the heat rapidly into the surrounding fresh air chambers. These chambers are included between the shells described, and they are entirely protected from the noxious gases of the fire, there being no joints or openings in the shells. The heating surfaces facing the air chambers, and upon which the inflowing current of pure air circulates, amount in the smallest sized grate to about 15⅔ superficial feet, and in the largest sized grate to 23½ feet. A valuable feature in these grates is, that, in consequence of the circulation of a current of air over the inner surface of the iron shell which forms the back and the sides of the basket in which the fire rests, these surfaces cannot be warped and broken by the action of the fire, and the grate thus is practically indestructible and will last a lifetime.

"CONCORD" PATTERN.

This form of the Heat-Saving and Ventilating Grate is constructed for uniformly heating and ventilating large rooms, and those that are in exposed situations, as are those in most country or village houses, and which the common form of grate, with an equal consumption of fuel, would be entirely inadequate to heat. It is adapted for burning hard or soft coal or wood. It has the full open front or fire-place, and the beauty, cheerful effect, and full radiating power of the ordinary grate, combined with threefold the heating capacity of the common grate. It was with this grate that the experiments were made by Mr. J. P. Putnam, architect, of Boston, Mass., the results of which are recorded in the work entitled "The Open Fireplace in All Ages." From these experiments it is shown that with the ordinary grate, "a little

less than 9 per cent. of the whole heat generated" is utilized in the heating of the room in which the grate is placed, while with the Jackson Heat-Saving and Ventilating Grate "twenty-seven per cent. is utilized" for heating purposes.

The construction of the grate is such that it is a constant ventilator in all seasons. In winter with a full fire and with the doors and windows effectually closed, the whole atmospheric contents of large rooms are replaced by pure warm air every fifteen or twenty minutes. For bedrooms, or for rooms communicating with bedrooms, these grates provide the most perfect automatic ventilation, maintaining a purity of atmosphere in them not sensibly less than that of the open air with the entire absence of the unpleasant and unhealthful draughts that accompany the usual modes of ventilation.

In a word, by the Heat-Saving and Ventilating Grate there is secured the full heating power of the stove or fireplace-heater, devoid of all the noxious effects of those forms of heating apparatus.

It is a truth that is rapidly becoming recognized by householders, that the heating apparatus employed in the dwelling should also perform the office of a ventilator for it. The chimney has been aptly called the lungs of a house, and where its office is unobstructed, it may prove a very efficient ventilator. Dr. Hartshorne, in the Health Primer entitled "Our Homes," says,—"Every room in the house, intended to be occupied, should have in it an open fire-place. Especially is it important for an open fire-place to be in every sleeping-chamber. For a sick person, the difference between a wood fire on the hearth and the usual heated air or coal stove in the room is immense. It may in critical cases make the turning-point between death and recovery."

There are, however, two prominent objections to the open fireplace, and to the ordinary form of fire-place grate: First, though they are excellent agencies for removing the air from the lower levels of the room (removing, as they frequently do, the whole air contents of the room once every fifteen or twenty minutes), they provide no means for supplying the vacuum thus produced, and thus they cause drafts of cold air about the windows and of impure air from the surrounding rooms. Second, they supply to the rooms in which they are placed but a very small fraction of

Fig. 11.

the whole heat product of the fuel. From the careful tests of Gen. Morin, the deduction is made "that of the heat generated by the fuel in an ordinary fire-place, about one eighth only is utilized in the room."

The Jackson Heat-Saving and Ventilating Fire-Place largely remedies both these defects. As will be seen by a reference to the accompanying engraving, fresh air from immediately outdoors is taken into a shaft directly under the grate, and enters a chamber beneath the fire, where it is partially heated, and thence passes into chambers surrounding the back and sides of the fire-place, and it conserves in these the heat that is usually lost in the brickwork of the fire-place. Passing thence in the direction of the arrows, this now heated current circulates about the tubular flues, five in number (one of which is distinctly shown in the cut), which convey the smoke to the chimney above. Finally, this heated air, which, it will be observed, is pure air from outside the building, enters the room through the open frieze of the grate-frame, and from its levity ascends in a current to the ceiling. A double office is thus fulfilled. A very large part of the heat usually lost in the fire-place is conserved and added to that directly radiated from the fire, making the grate equal in heating power to over three ordinary grates of the same size; and an amount of pure warm air, equal to that taken from the room by the exhaust of the chimney, enters from the heat-saving chambers, and thus all drafts from the windows and doors are prevented. A continually augmented volume of pure warm air, occupying the higher levels of the room, and a continual draft being made by the fire-place from the colder, impure air from the lower levels, keep up a constant atmospheric circulation, and thus automatically the room is thoroughly ventilated.

Figure 11 represents the cold air as being conducted under the grate by means of a flue constructed of wood, such as is generally used with a hot-air furnace; and in placing them in chimneys already up and in use, it will be found a convenient way of adapting the grate to the purpose required.

In the construction of a new house, the pure air from outside may be brought in more directly, as shown by Fig. 12; and a front and back view of the grate is introduced to show more clearly the

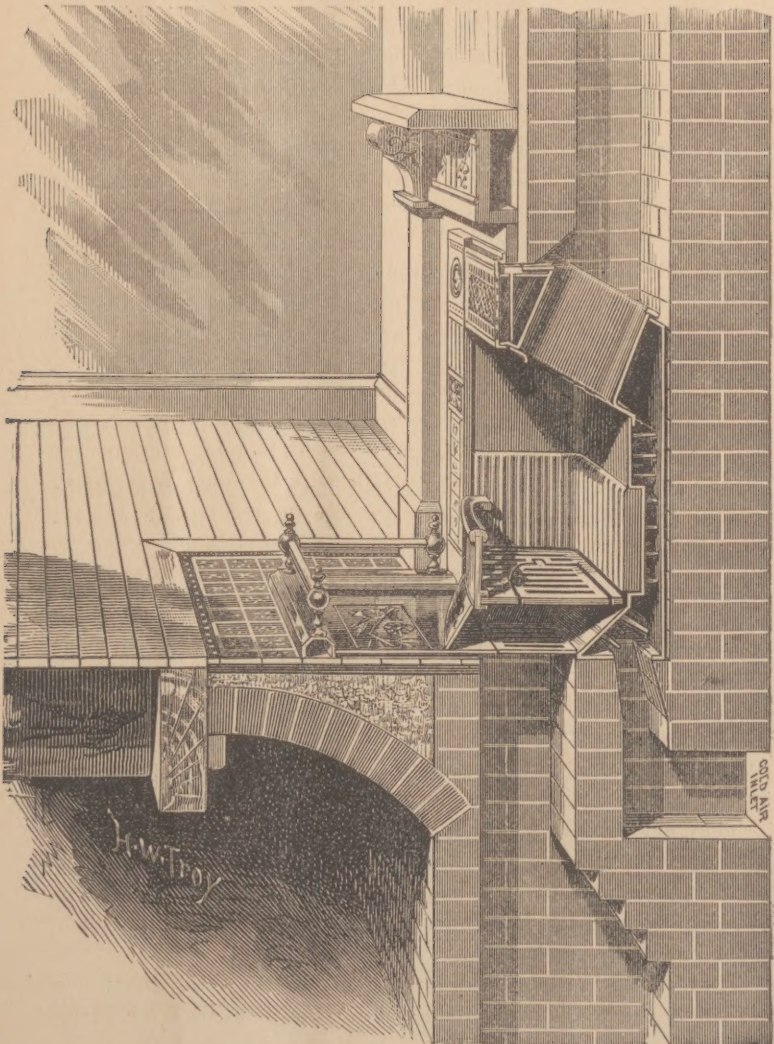

FIG. 12—*Section.*

practical working of it as a device for warming and ventilating an apartment in which it may be placed.

The essential requisites of a good fire-place are also given in the language of the designers, Edwin A. Jackson & Brother, 77 Beekman street, New York city.

Rightly constructed fire-places should and can be made to fill three essential conditions, that, named in the order of their importance, are as follows:

First. They should keep the rooms in which they are placed always filled with pure, circulating air. In winter this air should enter as a warm current, with a volume sufficient to change the whole air contents of the rooms at least every half hour. This volume should be adequate to fully supply the exhaust of the chimney, and thus to prevent any tendency to draughts of chilling air from the windows, or of impure air from other parts of the house, drawn under the doors.

Second. They should be essentially heating apparatuses, fully competent to thoroughly warm the rooms in which they are situated without the aid of furnace heat. To effect this result they must possess about three times the heating power of ordinary grates, seven eighths of whose heat is wasted in the chimney.

Third. They should be large, generous fire-places, with their cheering, healthful, radiant, blazing fires, as near as may be similar to the famous fire-places of olden time.

The fire-places most in vogue now, fill the last condition only, and in many cases fail even in this, being often liable to smoke and deficient in power to produce a brilliant fire.

They obtain their whole supply for the chimney draught from air drawn in, piercing cold, from around the doors and windows, and thus produce currents that are detrimental to health. Where this is prevented by close-fitting doors and windows, the fire-place must inevitably smoke.

They utterly fail to heat large rooms, since only about one eighth of the whole heat product of the fuel is utilized for warming the room, the rest being lost in the brickwork of the chimney, or dissipated up and through the chimney flue.

The above described fire-place fills all the three conditions named.